Micro/Nano Spacecraft Thermal Control using MEMS based Pumped Liquid Cooling Systems

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The thermal control of future micro/nano spacecraft is expected to be very challenging due to increased electronic and other payload power densities which are expected to exceed 25 Watts/cm^2. Advanced thermal control concepts and technologies are required to keep their payload within allowable temperature limits. A MEMS based pumped liquid cooling system is being investigated at Jet Propulsion Laboratory (JPL) for the thermal control of high power density electronics and other payload on future micro/nano spacecraft. The mechanically pumped cooling system consists of a working fluid circulated through microchannels by a micropump; it provides many advantages over passive thermal control concepts and technologies. First, the working fluid in the cooling loop provides efficient coupling to the hot surface of the electronics. Second, the cooling loop provides flexibility in locating the heat sink inside the spacecraft. Third, the cooling loop potentially provides a simple mating to semiconductor surfaces through bonding techniques. Furthermore, the MEMS cooling system can be easily integrated with the spacecraft thermal control system.

Microchannel heat sinks have been designed and fabricated in silicon at JPL and are currently being tested for hydraulic and thermal performance in simulated microspacecraft heat loads using water as the working fluid. The microchannels are 50 microns deep with widths ranging from 50 to 100 microns. The hydraulic and thermal test data is used for numerical model validation. Optimization studies are being conducted using these numerical models on various microchannel configurations, working fluids, and micropump technologies. This paper presents background on the need for pumped liquid cooling systems for future micro/nano spacecraft and results from this ongoing experimental investigation.